CERES products vs MOSAiC observations: Investigation of discrepancies

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Combining MOSAiC and Satellite Observations for Radiative Closure and Climate Implications
(MOSaRiCs)

Carola Barrientos-Velasco, Hartwig Deneke, Anja Hünerbein, Hannes J. Griesche, Patric Seifert and Matthew Shupe

Leibniz Association

MOSAiC International Arctic Drift Expedition

Bundesministerium für Bildung und Forschung

TROPOS Leibniz Institute for Tropospheric Research

Motivation

Surface radiation important component determining surface energy budget

'The CERES Cloud Radiative Swath (CRS) for process-Level Polar Surface Radiation budget studies'

Kato et al., 2022 (AMS)

How to extrapolate a point measurement to the CERES footprint?

Broadband radiative flux comparison between CERES SYN 1deg products Ed.4.1 (hourly resolution 1°x1°) and ground/ship based observations during MOSAiC (Multidisciplinary drifting Observatory for the Study of Arctic Climate)

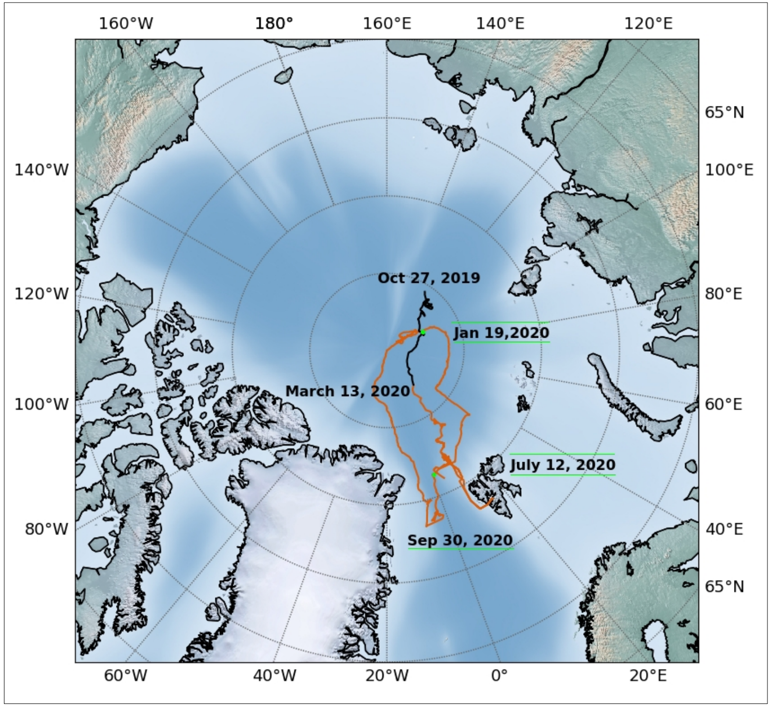
MOSAiC data

- Macro- and microphysical properties of clouds (Cloudnet algorithm)
- 1-5 stations measuring Broadband LW and SW fluxes 1 second resolution

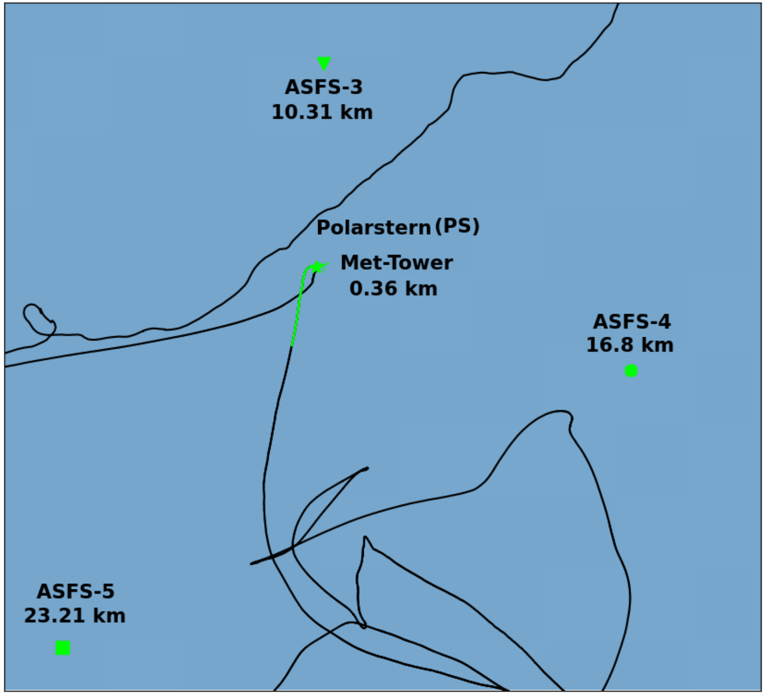
Performed simulations

- 1D radiative transfer model (RRTMG) used Cloudnet products, atmospheric profiles of temperature and humidity, and surface properties as input parameters

Polarstern drifting track



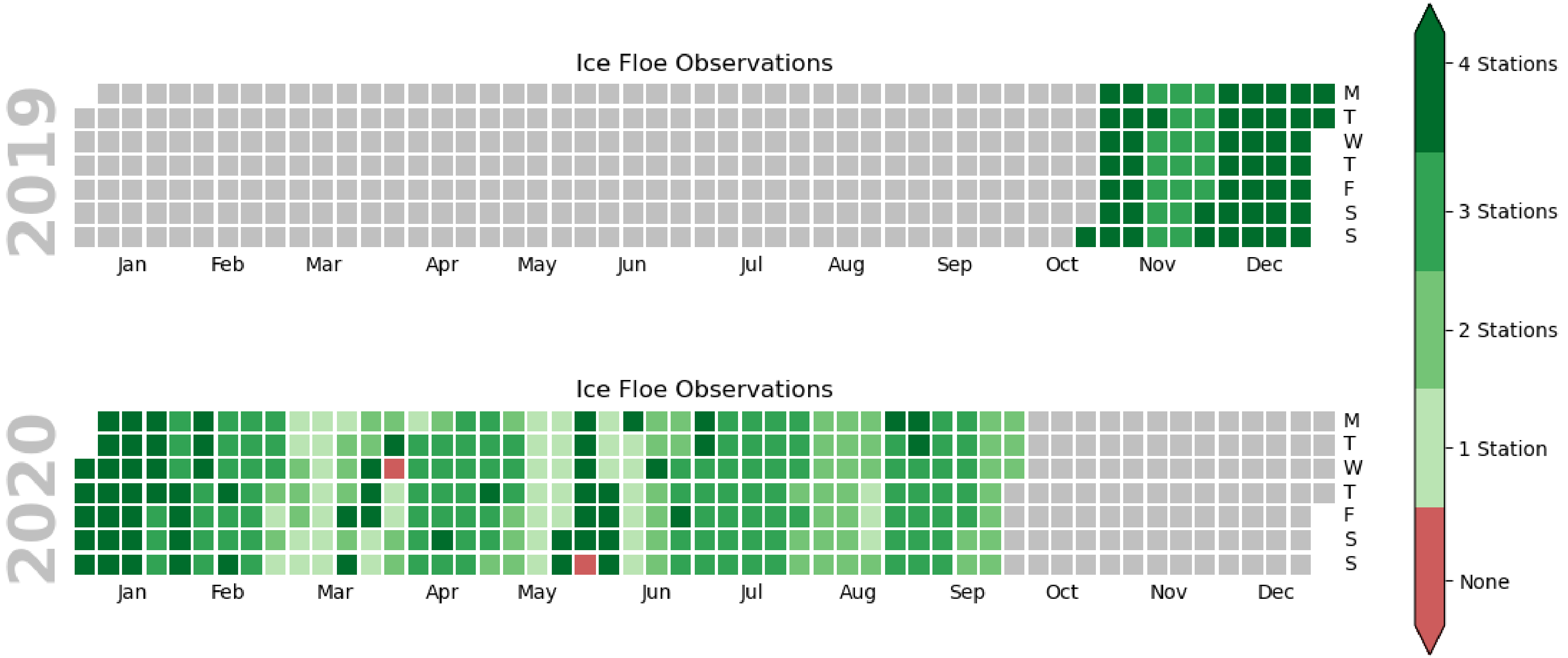
Station during MOSAiC (January, 19 2020)



Distance to Polarstern (PS)
Automated Surface Flux Stations (ASFS)

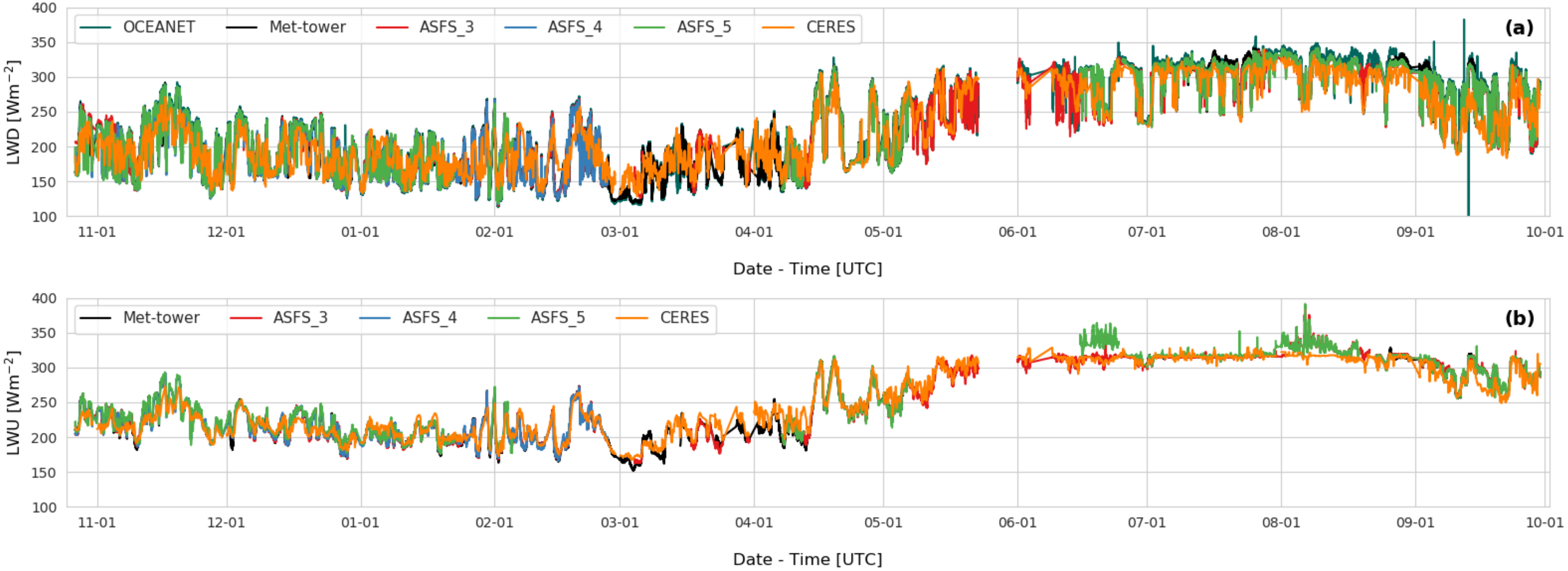
Dataset

Calendar showing the temporal coverage of ice-floe observations during MOSAiC



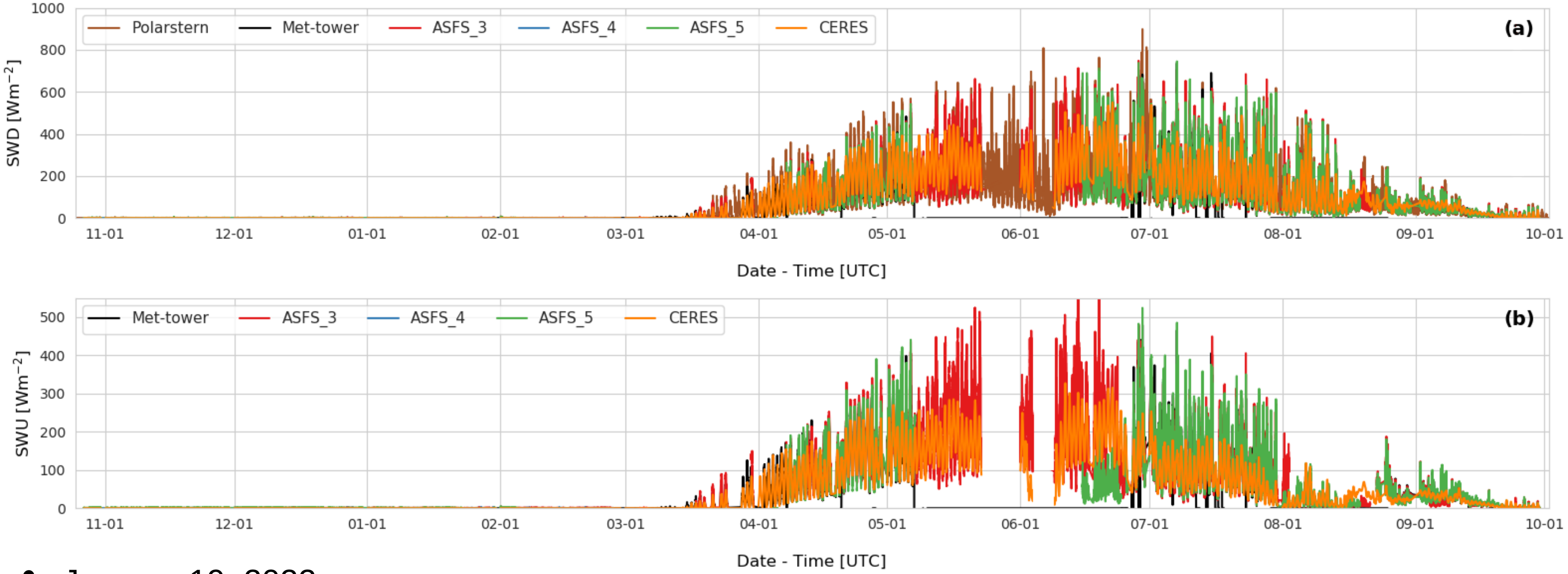
Time series of broadband radiative fluxes

Broadband LW radiative fluxes



Time series of broadband radiative fluxes

Broadband SW radiative fluxes

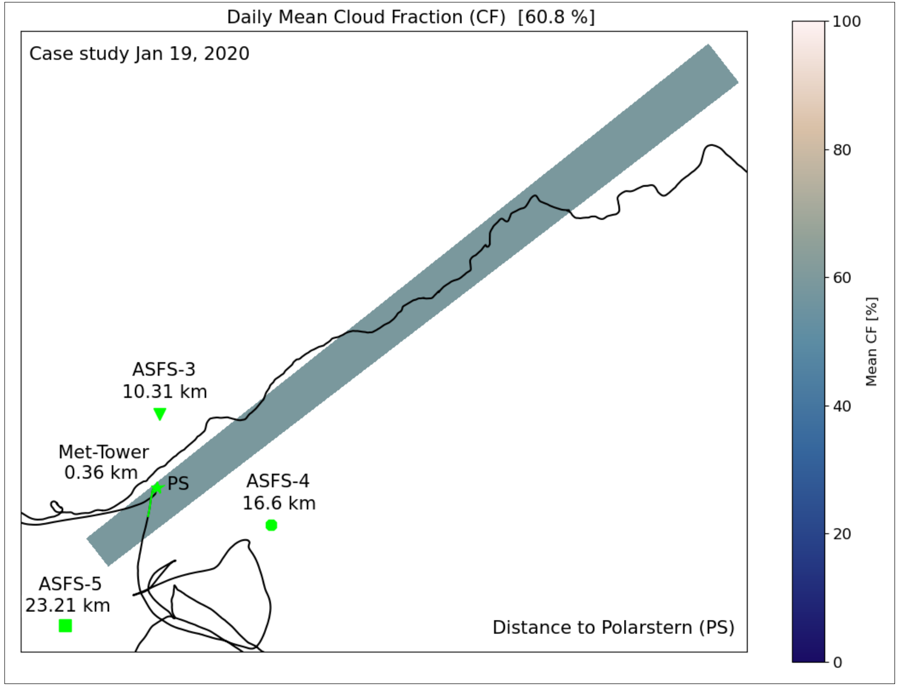


- January 19, 2022
- July 12, 2022

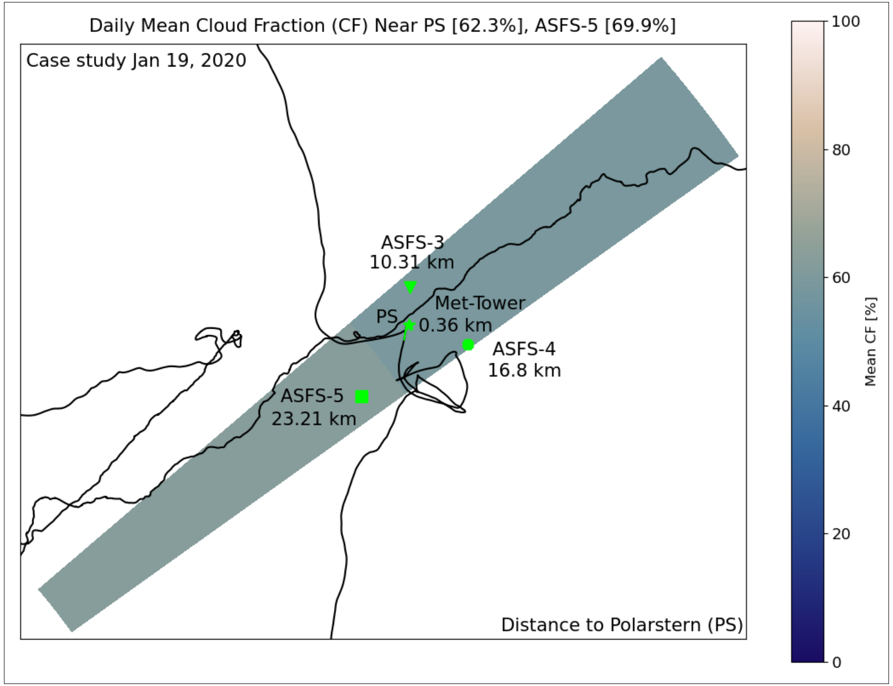
Results

Case study January 19, 2020

CERES SYN Ed4.1 1°x1°* collocation to PS



CERES SYN Ed4.1 2°x5°* collocation to all observations



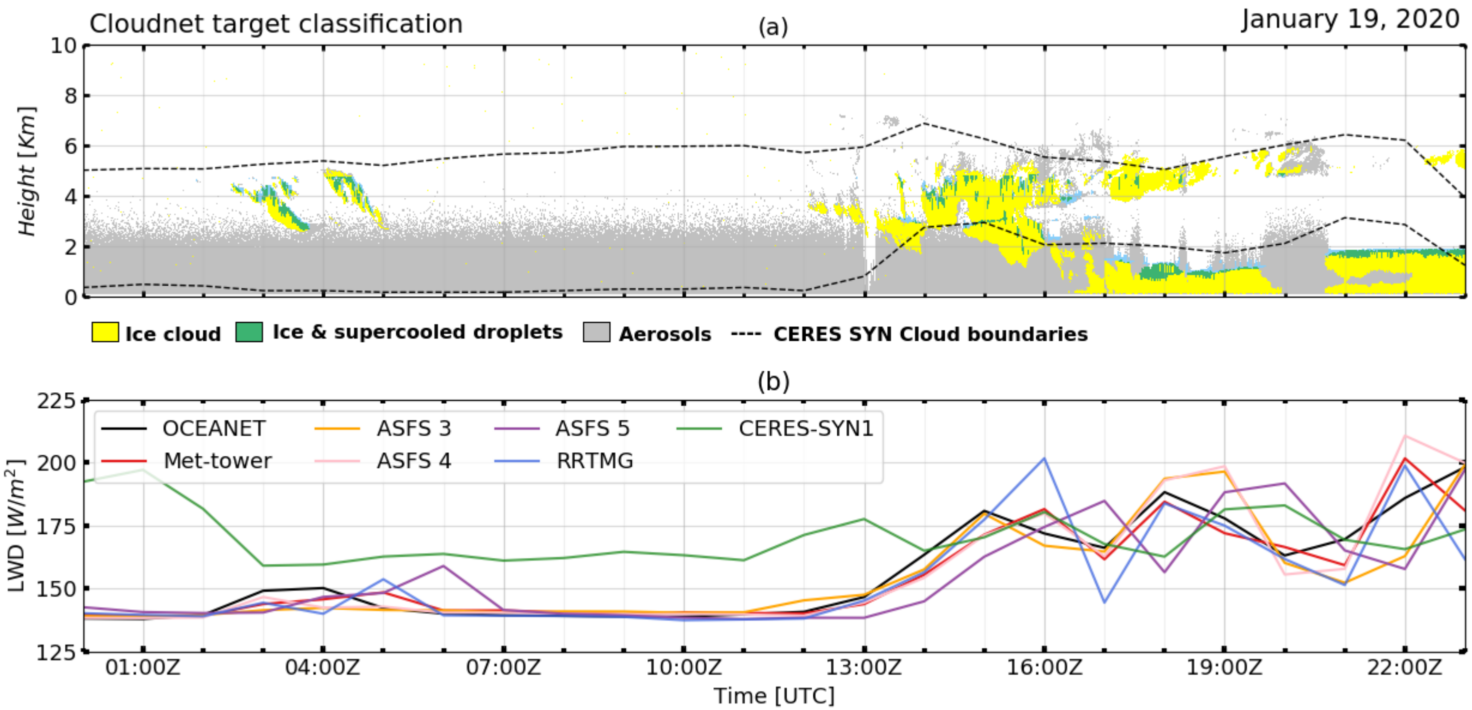
* lat x lon

Results

Case study January 19, 2020

Hourly time series of cloud conditions and radiative fluxes

CERES SYN collocated to PS position

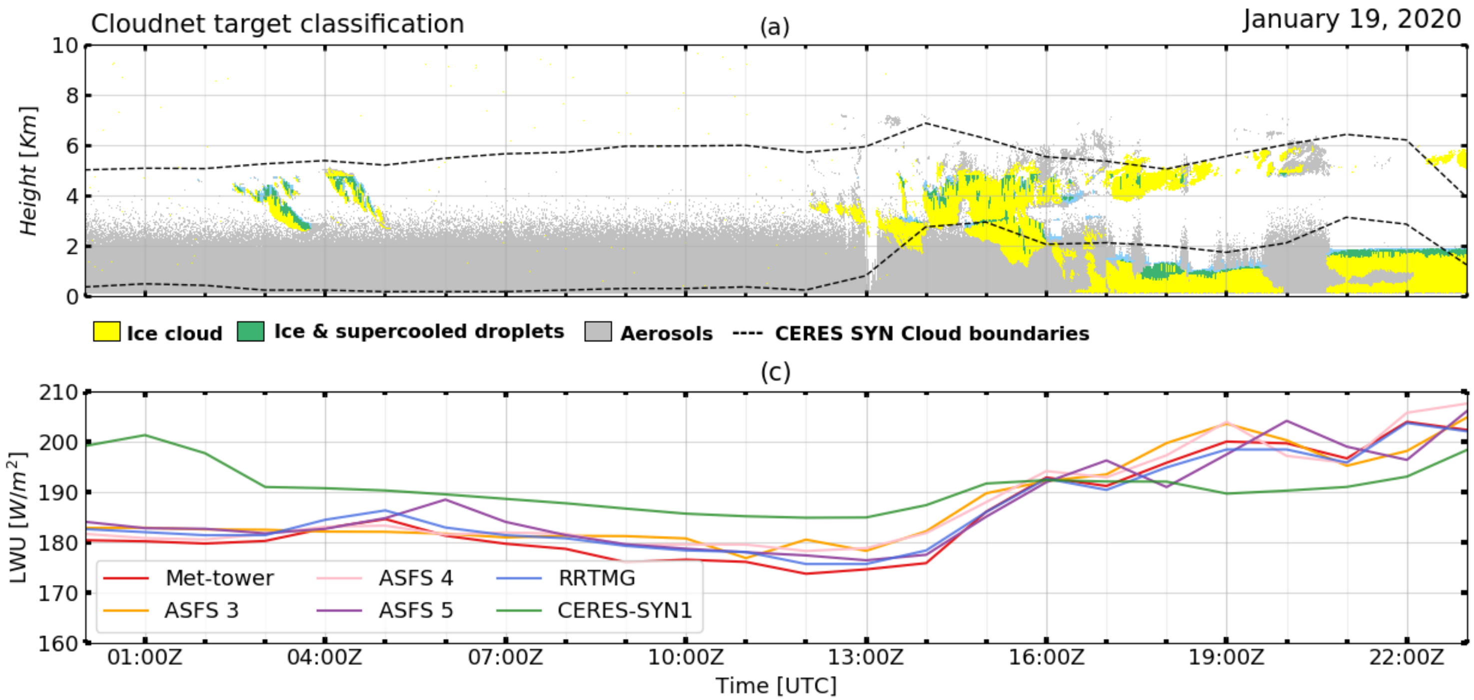


Results

Case study January 19, 2020

Time series of cloud conditions and radiative fluxes

CERES SYN collocated to PS position

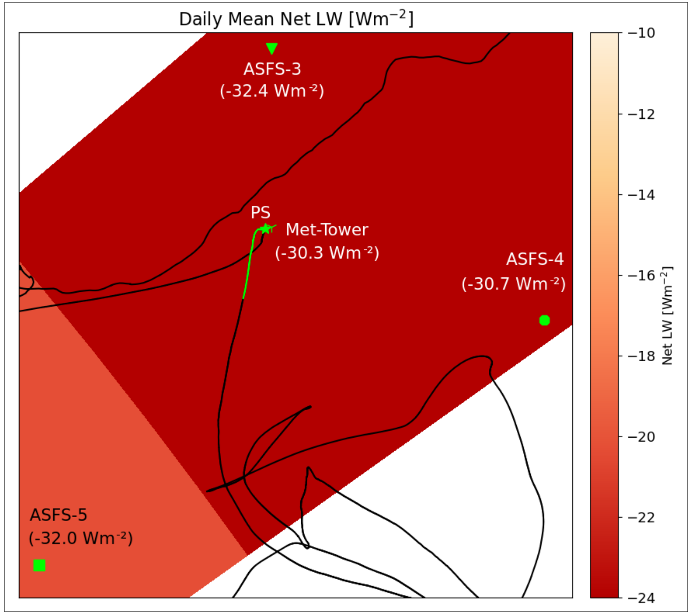


Results

Case study January 19, 2020

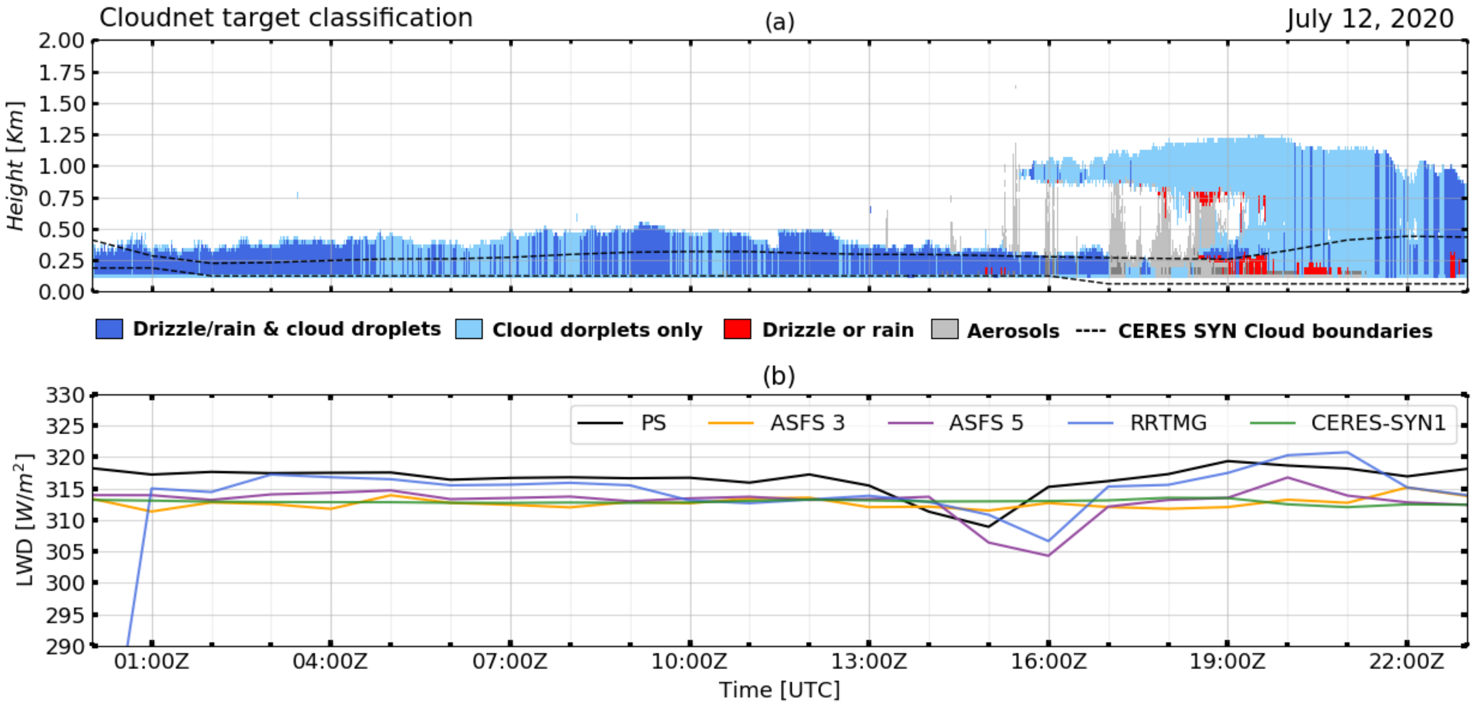
Collocated simulations to observations [1°x1°]

Flux difference [W/m²]	PS (OCEANET) (SD 2.8 W/m² LWD)	ASFS 3	ASFS 4	ASFS 5
ΔLWD CERES SYN -Obs.	14.6 (OCEANET) 15.7 (Met-Tower)	15.9	14.2	15.9
ΔLWU CERES SYN -Obs.	5.0 (Met-Tower)	3.6	3.5	3.9
ΔLWD RRTMG - Obs.	-2.6 (OCEANET) -1.4 (Met-Tower)	-1.2	-2.9	-1.3
ΔLWU RRTMG -Obs.	0.9 (Met-Tower)	-1.0	-1.0	-0.7



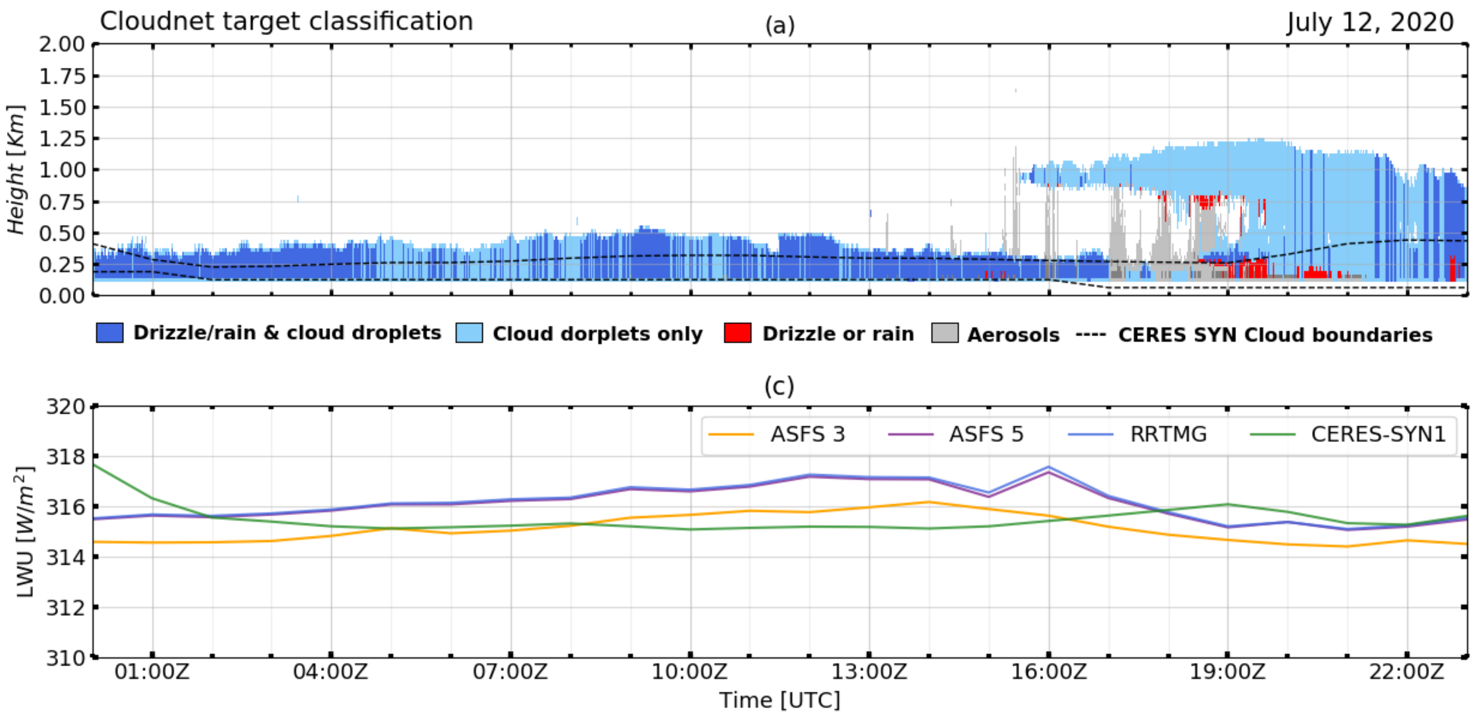
Results

Case study July 12, 2020



Results

Case study July 12, 2020

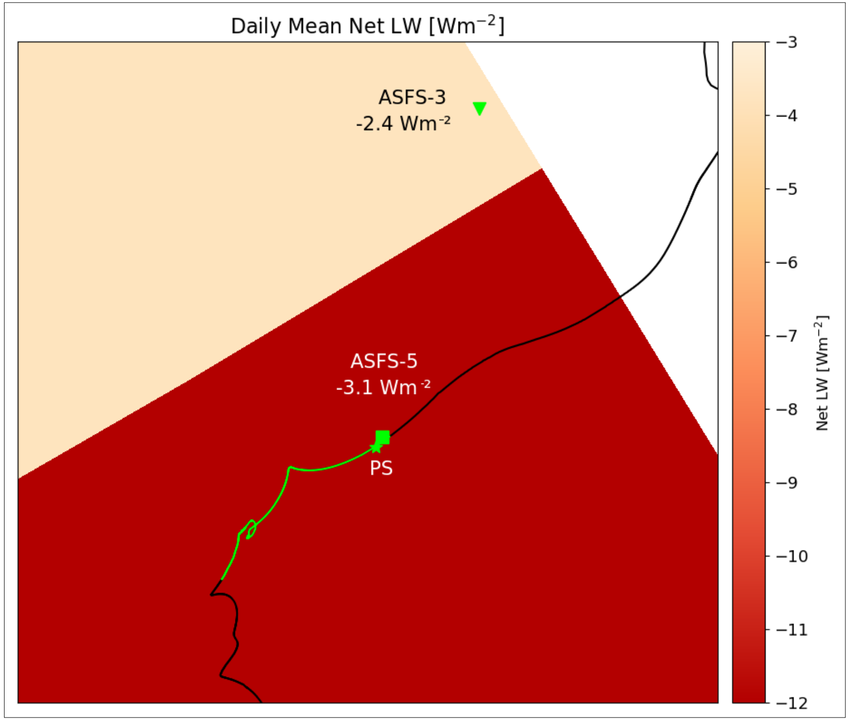


Results

Case study July 12, 2020

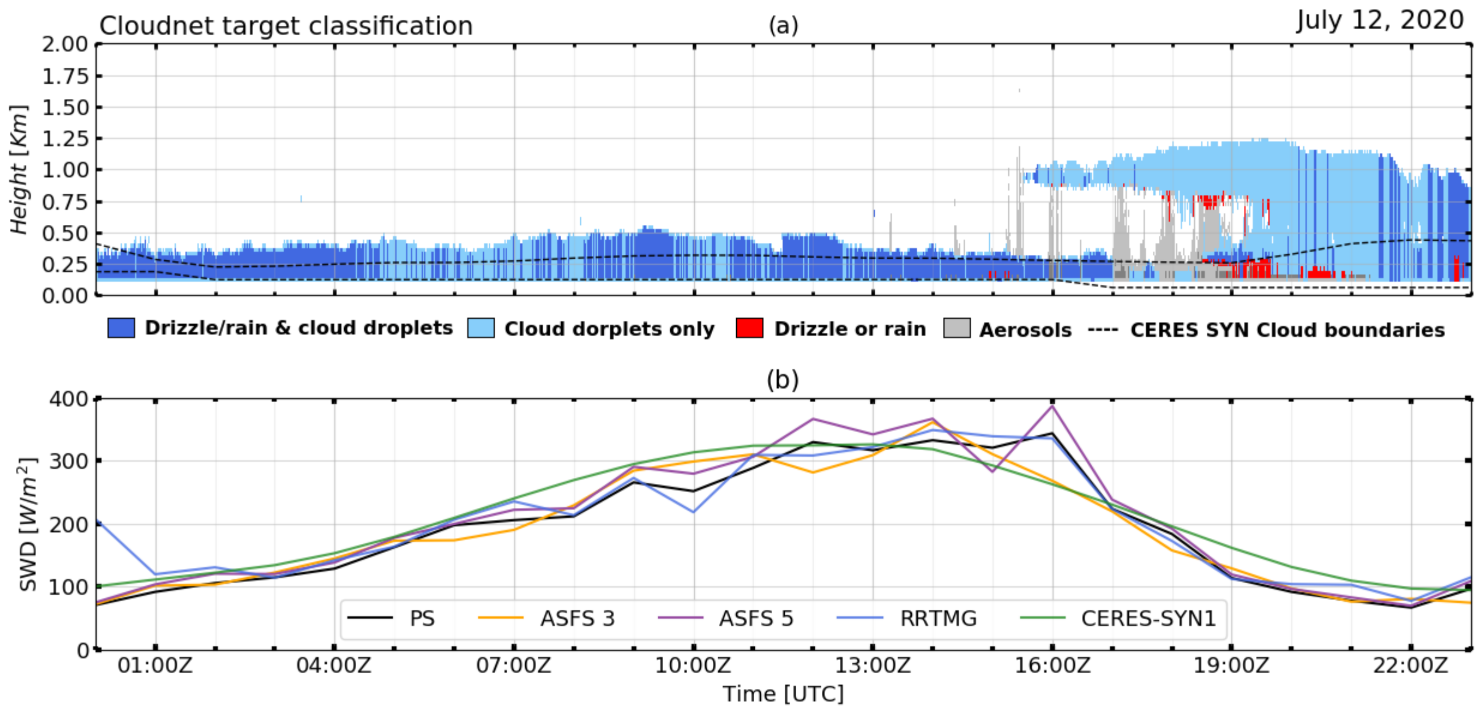
Collocated simulations to observations [1°x1°]

Flux difference [W/m²]	PS (OCEANET) (SD 1.9 W/m² LWD)	ASFS 3	ASFS 5
ΔLWD CERES SYN -Obs.	-3.7	0.2	-0.04
ΔLWU CERES SYN -Obs.	-	0.4	-0.6
ΔLWD RRTMG - Obs.	-4.2	-0.3	-0.5
ΔLWU RRTMG -Obs.	-	1.0	0.06



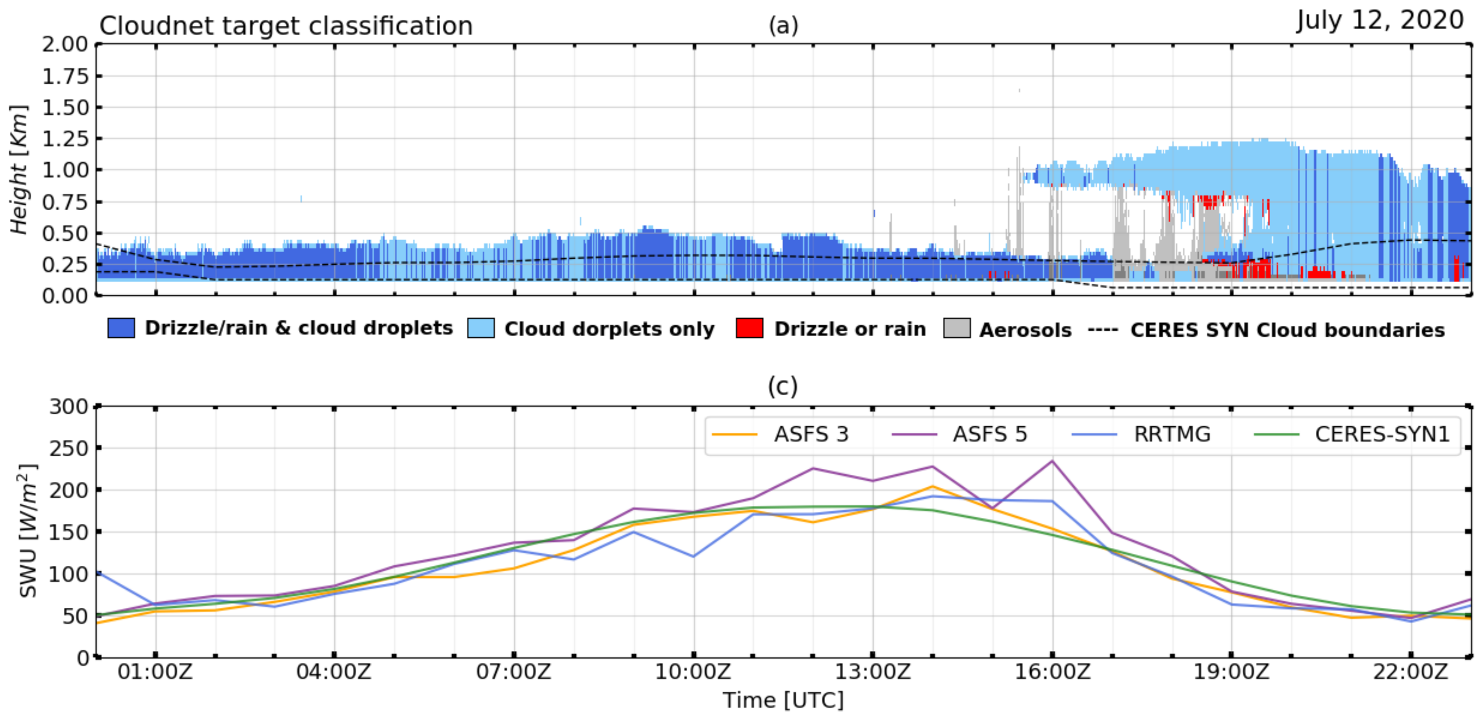
Results

Case study July 12, 2020



Results

Case study July 12, 2020

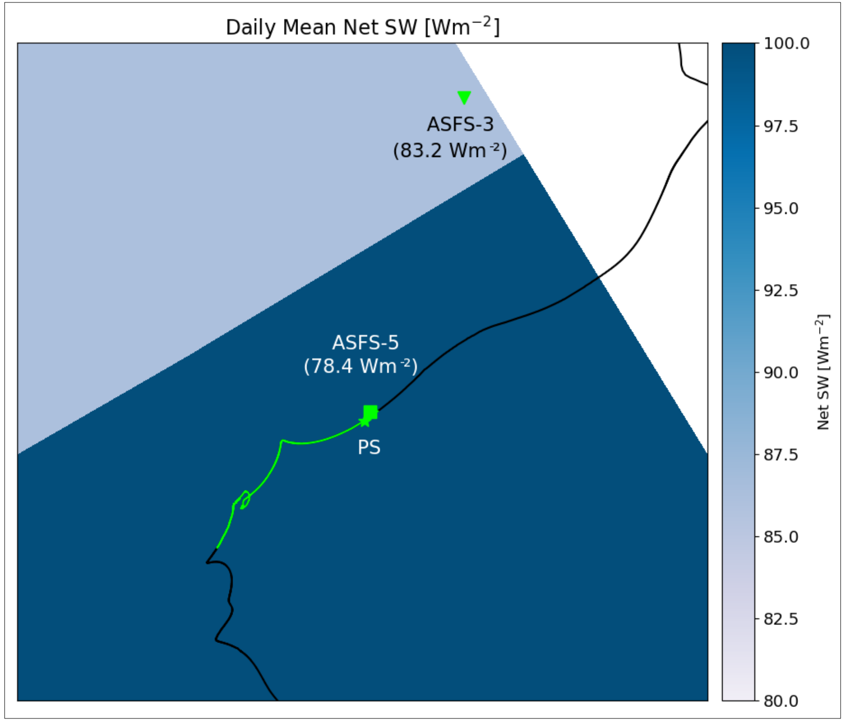


Results

Case study July 12, 2020

Collocated simulations to observations [1°x1°]

Flux difference [W/m²]	PS-R (region) (SD 8.2 W/m² SWD)	ASFS 3	ASFS 5
ΔSWD CERES SYN -Obs.	16.8 (Polarstern)	17.8	3.6
ΔSWU CERES SYN -Obs.	-	5.8	-13.2
ΔSWD RRTMG -Obs.	12.6 (Polarstern)	13.6	-0.6
ΔSWU RRTMG -Obs.	-	3.2	-15.7



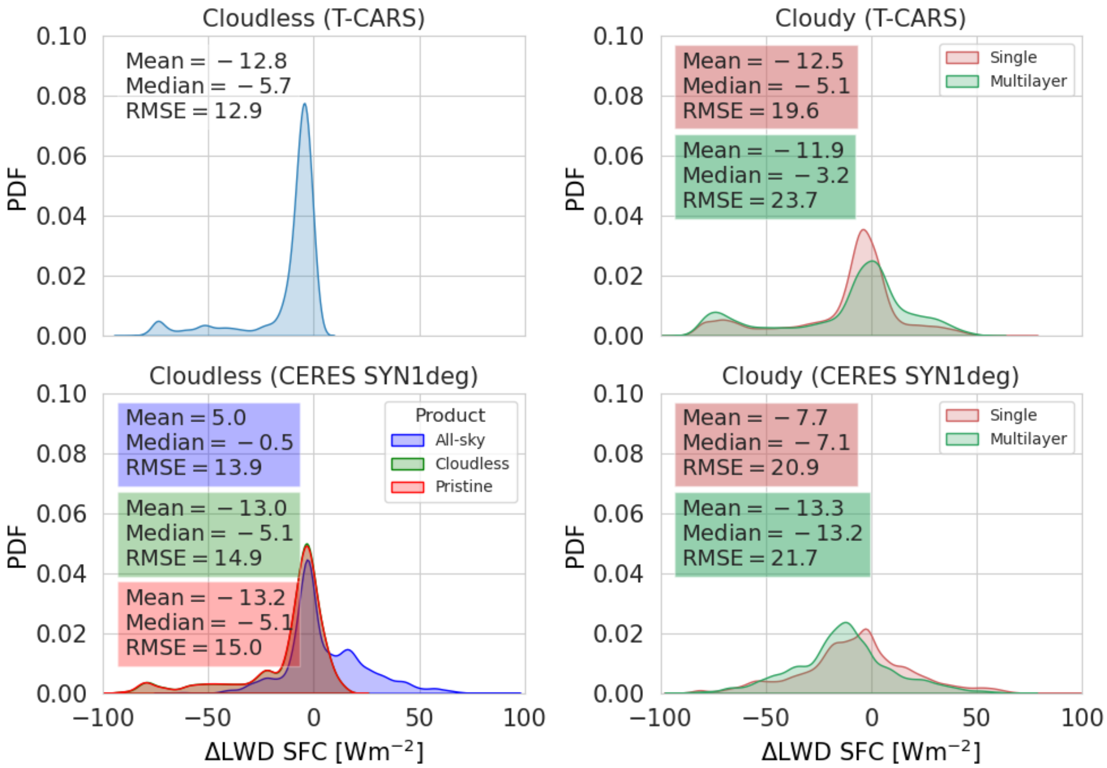
Summary and Outlook

- Systematic deviations are more significant during variable cloud conditions
- Collocation to each station might be necessary for some cases, specially during summer *(Huang et al., 2022, Webster et al., 2022)*
- Variability among stations should be quantified while comparing CERES SYN products to observations
- During summer, sky camera images can be useful to identify clear-sky and broken cloud conditions
- Spatial scale effect on flux comparison between CERES SYN and 1D radiative simulations based on ship-borne remote sensing observations
- CERES Cloud Radiative Swath can be analyzed in the future

Thank you for your attention

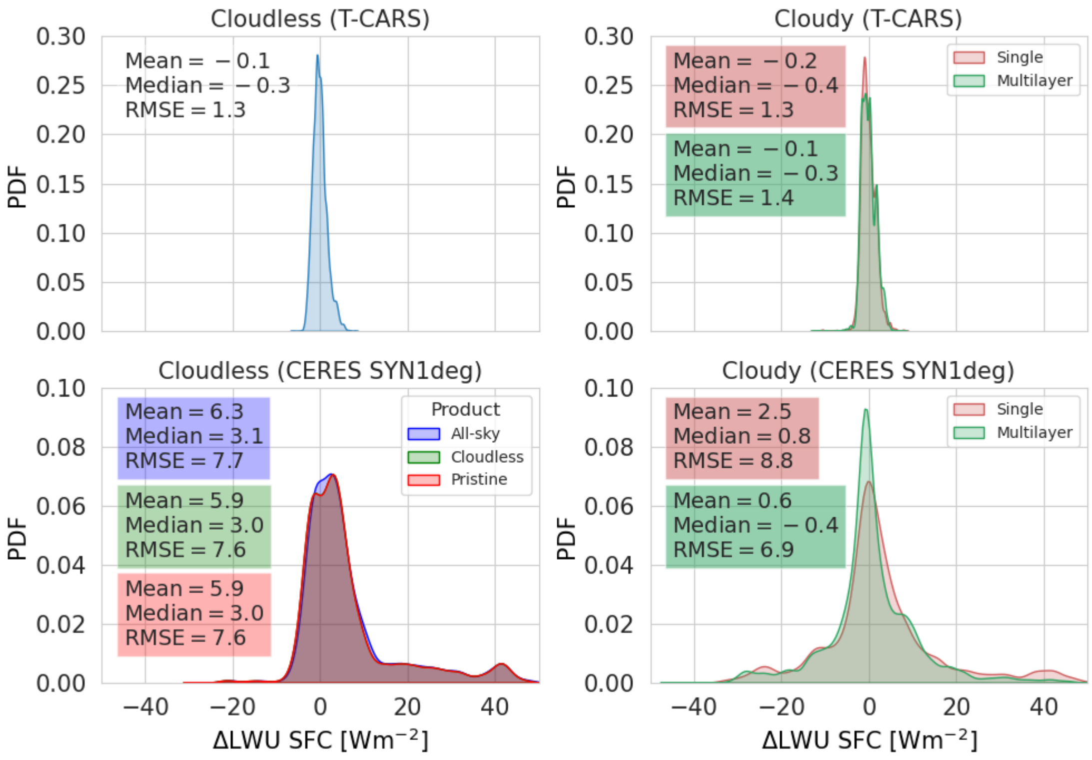
Backup - Slides

LWD



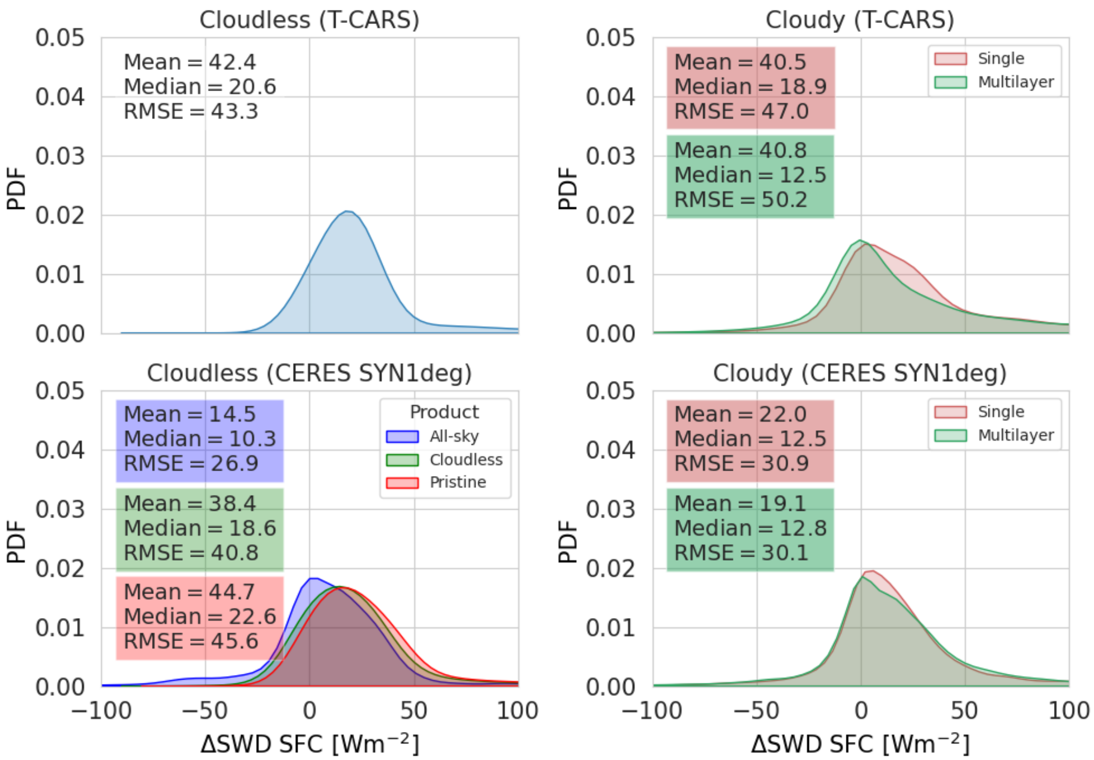
Cloudless (T-CARS)
Mean = − 12.8
Median = − 5.7
RMSE = 12.9
Cloudy (T-CARS)
Mean = − 12.5
Median = − 5.1
RMSE = 19.6
Mean = − 11.9
Median = − 3.2
RMSE = 23.7
Single
Multilayer
Cloudless (CERES SYN1deg)
Mean = 5.0
Median = − 0.5
RMSE = 13.9
Mean = − 13.0
Median = − 5.1
RMSE = 14.9
Mean = − 13.2
Median = − 5.1
RMSE = 15.0
Product
All-sky
Cloudless
Pristine
Cloudy (CERES SYN1deg)
Mean = − 7.7
Median = − 7.1
RMSE = 20.9
Mean = − 13.3
Median = − 13.2
RMSE = 21.7
Single
Multilayer
PDF
ΔLWD SFC [Wm⁻²]

LWU



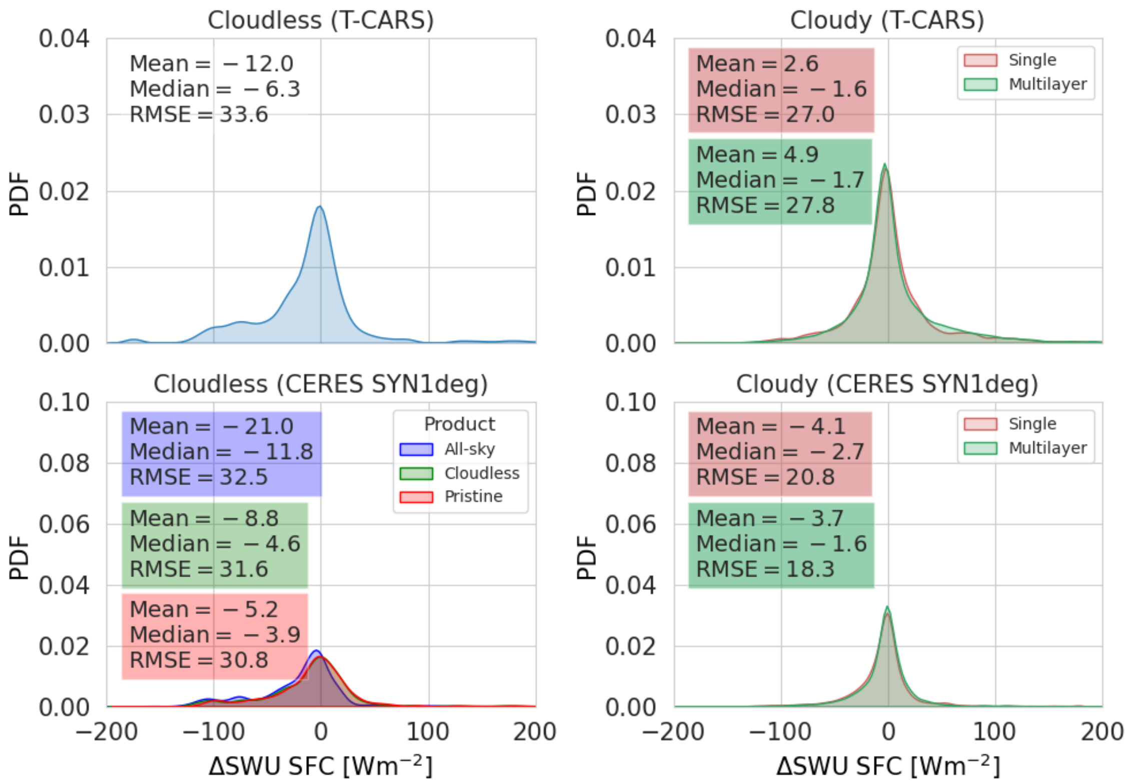
Cloudless (T-CARS)
Mean = −0.1
Median = −0.3
RMSE = 1.3
Cloudy (T-CARS)
Mean = −0.2
Median = −0.4
RMSE = 1.3
Mean = −0.1
Median = −0.3
RMSE = 1.4
Single
Multilayer
Cloudless (CERES SYN1deg)
Mean = 6.3
Median = 3.1
RMSE = 7.7
Mean = 5.9
Median = 3.0
RMSE = 7.6
Mean = 5.9
Median = 3.0
RMSE = 7.6
Product
All-sky
Cloudless
Pristine
Cloudy (CERES SYN1deg)
Mean = 2.5
Median = 0.8
RMSE = 8.8
Mean = 0.6
Median = −0.4
RMSE = 6.9
Single
Multilayer
PDF
ΔLWU SFC [Wm⁻²]

SWD



Cloudless (T-CARS)
Mean = 42.4
Median = 20.6
RMSE = 43.3
Cloudy (T-CARS)
Single
Multilayer
Mean = 40.5
Median = 18.9
RMSE = 47.0
Mean = 40.8
Median = 12.5
RMSE = 50.2
Cloudless (CERES SYN1deg)
Product
All-sky
Cloudless
Pristine
Mean = 14.5
Median = 10.3
RMSE = 26.9
Mean = 38.4
Median = 18.6
RMSE = 40.8
Mean = 44.7
Median = 22.6
RMSE = 45.6
Cloudy (CERES SYN1deg)
Mean = 22.0
Median = 12.5
RMSE = 30.9
Mean = 19.1
Median = 12.8
RMSE = 30.1
PDF
ΔSWD SFC [Wm⁻²]

SWU



Cloudless (T-CARS)
Mean = −12.0
Median = −6.3
RMSE = 33.6
Cloudy (T-CARS)
Mean = 2.6
Median = −1.6
RMSE = 27.0
Mean = 4.9
Median = −1.7
RMSE = 27.8
Single
Multilayer
Cloudless (CERES SYN1deg)
Mean = −21.0
Median = −11.8
RMSE = 32.5
Mean = −8.8
Median = −4.6
RMSE = 31.6
Mean = −5.2
Median = −3.9
RMSE = 30.8
Product
All-sky
Cloudless
Pristine
Cloudy (CERES SYN1deg)
Mean = −4.1
Median = −2.7
RMSE = 20.8
Mean = −3.7
Median = −1.6
RMSE = 18.3
Single
Multilayer
PDF
ΔSWU SFC [Wm⁻²]